Fast Matching System for Personal Identification

Field of the Invention

The present invention relates to personal identification, and more particularly, to a fast matching system for automatic personal identification.

Background

There has always been a need for personal identification. With the advances in technology, there is a desire to make the process of personal identification as streamlined as possible by increasing the efficiency and reliability of the methods. Traditional identification methods of requiring identification cards, passwords, codes, etc., are deemed cumbersome and outdated. Thus, there is a desire to take advantage of automated technology to determine a person's identity.

Efforts have been made to utilize biometric information to determine a person's identity. Examples of such efforts include utilizing fingerprints, retinal scans and iris scans. Many of such efforts have focused on verifying, as opposed to identifying, a person's identity. Verifying an identity is a relatively easier situation. With verification, an individual claims a certain identity and then the identification system compares the identification information of the individual with a stored set of identification information for the person they claim to be. This is a one-to-one comparison. Thus, the system merely needs to find the claimed identification information set and compare it to the set of identification information supplied by the individual making the claim.

On the other hand, pure identification is a more difficult problem as the individual does not first make a claim as to their identity, but the system must ascertain it. In this case, the system must compare the identification information supplied by the individual

with a large database comprising the identification information of individuals in a large population. This is known as a one-to-many comparison. Thus, the identification of an individual is relatively much more difficult than the verification of an individual's identity.

For example, U.S. Patent No. 4,641,349 discloses an iris recognition system. The system illuminates an eye, obtains an image of the iris and pupil of the eye, and compares the obtained image with stored image information to identify the eye. Further, the system illuminates the eye to drive the pupil of the eye to a predetermined size, which may then be compared with stored image information from an eye with the same pupil size. The system compares visible features of the iris such as pigment-related features, to stored images of irises to make an identification. The comparison methods identified by this patent include comparing pixel-by-pixel images of two eyes, optical signal processing, and a method in which visual features such as pigment spots are compared between two images. No method is identified, however, for maximizing the efficiency of this comparison.

Similarly, U.S. Patent No. 5,291,560 discloses a biometric personal identification system based on iris analysis. This system acquires a live video of a person's iris and encodes its texture into a compact signature, or iris code. A coordinate system is utilized to identify portions of the iris, and the iris information from the coordinate system is converted into a 256-byte iris code. The iris code has a universal mathematical format and constant length, allowing comparisons between codes using logical operations to determine iris identification. The comparison results in a similarity metric that positively establishes, confirms, or disconfirms the identity of any individual and establishes a confidence level associated with any such identification decision.

None of the prior art, however, identifies techniques for increasing the likelihood of finding a match at the earliest point possible in the comparison process. As such, methods are desired to increase the speed of the identification process.

Summary of the Invention

According to an embodiment of the present invention, a fast matching system for personal identification, preferably by comparing an acquired iris to a stored image of an iris, comprises an image acquiring device, and a computing device for converting the image into image data and determining a match between the image data of a stored image and the acquired image based upon an ordered search. The ordered search may comprise a number of different formats, depending on the requirements of the owner of the system.

The ordered search utilizes a selected set of image data comprising a subset of the entire database of stored image data. The data set to be searched is determined by concentrating on predetermined factors that increase the likelihood of finding a match early in the match determination process. The ordered search, for example, may focus on a characteristic of the iris, a characteristic of the individual, or some other characteristic determined by the owner of the system to enhance the identification speed of the system.

According to another embodiment of the present invention, a fast matching system for personal identification, preferably by comparing an acquired iris to a stored image of an iris, comprises an image acquiring device, and a computing device for converting the image into image data and determining a match between the image data of a stored image and the acquired image based upon binning the image data. The method of binning the image data from the acquired image and the stored images involves finding distinctive portions of the image data that consistently provide a match. The distinctive portions of the image data are utilized to sort the image data of the stored irises into different bins. The distinctive portion of the acquired image is utilized to find bins

containing stored data images with similar distinctive portions, thereby increasing the likelihood of finding a match.

According to yet another embodiment of the present invention, a fast matching system for personal identification, preferably by comparing an acquired iris to a stored image of an iris, comprises an image acquiring device, a carousel device for presenting a plurality of stored images at one time, and a computing device for converting the image into image data and determining a match between the image data of a stored image and the acquired image. The carousel device is analogous to a rotating carousel of iris images that allows the images to be viewed through a plurality of windows at one time.

Brief Description of the Drawings

Fig. 1 is a schematic diagram of the system of the present invention; and

Fig. 2 is a flow chart of the process of the present invention.

Detailed Description of the Invention

Referring to Figs. 1 and 2, according to a preferred embodiment of the present invention, a fast matching system 10 for personal identification comprises a camera 12 that acquires a presented image 14, such as an iris 16 of an eye 18 that is within its field of view 20. A processor 22 receives signal 24, representing iris 16 and other individual characteristics, that is converted into a presented image metric, which is in a readily analyzable format. The presented image metric is then compared to data 26 representing stored image metrics from a stored image database 28 in order to determine the identity of the individual. The stored image metrics may comprise a set of image metrics grouped or binned together based on certain characteristics. Alternatively or in conjunction with the binned image metrics, the presented image metric is compared to image metrics stored in a carousel system that provides a concurrent comparison of a plurality of

presented image metrics with each of a series of stored image metrics. Additionally, the presented image metric may be compared with stored image metrics stored locally, such as within memory 30, or processor 22 may communicate 32 with a remote device 34 that comprises a stored image metric database 36, within memory 38, which may have the capability to contain more stored images than in a local database. If a match is not found, the system may return to the step of selecting a set of stored image metrics, searching stored image metrics in the carousel device, or ending the identification process. If an identification is found, the system ends the identification process.

Camera 12 may be any type of image gathering device. System 10 may additionally utilize camera 12 to detect features of the individual other than their iris 16. For example, camera 12 may have a field of view 20 large enough to find portions of an individual's body, such as the head, while still being able to focus in on eye 18 and then iris 16. System 10 may advantageously utilize field of view 20 of camera 12 to detect individual characteristics such as hair color, skin tone, facial characteristics, etc. Alternatively, camera 12 may comprise a plurality of cameras, such as a Wide Field of View (WFOV) camera and a Narrow Field of View (NFOV) camera in order for system 10 to capture both individual characteristics and iris characteristics. Thus, camera 12 in combination with system 10 is able to ascertain general distinctive individual characteristics as well as identify and focus in on the distinctive characteristics of iris 16 of an individual.

The presented image metric comprises data formatted to represent detailed characteristics of presented image 14, which may include data formatted to represent individual characteristics, as described above. Data representing presented image 14 and individual characteristics are preferably converted into a digital data format that accurately reflects the various image features and characteristics in a consistent and repeatable manner. The data format allows for quick analytical comparison of data representing the presented image to data representing a stored image. Data for stored

images are acquired and entered in the stored image database during a secure process that reliably identifies the individual. The various descriptive features of presented image 14, such as the contours of the iris 16 of an eye 18, are converted into the data format such that two independent images having similar features have the corresponding portions of their data formatted similarly. Thus, the presented image metric is compared to a previously acquired and verified stored image metric in order to determine the identity of an individual.

System 10 may allow an identity determination based on a plurality of different match determination methods. One embodiment of a match determination method comprises an ordered search. The ordered search utilizes a selected set of stored image metrics comprising a subset of the entire database of stored image metrics. The subset to be searched is determined by sorting the entire database of stored image metrics based on portions of the data format that represent a selection of distinctive characteristics that are either a part of the stored image metric or that are associated with the stored image metric. These distinctive characteristics increase the likelihood of finding a match early in the match determination process. The ordered search, for example, may focus on individual characteristics, defined characteristics, or binned image metric characteristics to enhance the identification speed of the system.

The individual characteristics may comprise features like the hair color, skin tone, and distinctive facial characteristics of an individual, for example. These characteristics may be captured by the camera and form the primary portion of the presented image metric and the stored image metrics. For example, one primary individual characteristic preferably comprises the iris of an individual. Utilizing the iris for identification is desirable because, like a fingerprint each iris is unique. Additionally, iris identification is advantageous in thwarting impostors because it is risky to alter the contour of the iris. Thus, the difficulty of creating an impostor image increases the security level of an iris identification.

The presented image metric represents the contours and pigmentation of the iris, as well as other general individual characteristics, and can be quickly compared to other stored image metrics to make an identification determination. A plurality of individual image characteristics may be combined into the presented image metric to aid the fast matching ability of the system. Also, individual characteristics that most humans use to identify other humans may be utilized to quickly determine a subset of stored images to search. For example, a subset may comprise stored image metrics of individuals with brown eyes, light brown skin and dark brown hair, possibly along with some other distinctive iris characteristic.

Similarly, the ordered search may comprise other defined characteristics that are not related to an individual's appearance. The defined characteristics may comprise a portion of the presented image metric and the stored image metrics, or the defined characteristics may just be associated with or linked to the image metrics. These defined characteristics may be initially established at the same time as the stored image is securely entered into the database, and/or updated periodically. Also, these defined characteristics may provide subsets of stored images based upon geography, memberships, affiliations, or individual habits. For example, the system may perform an ordered search first from a subset of stored image metrics of the last 500 individuals to utilize the system; then all individuals with addresses within a certain radius of the system, then all individuals who are a member of the CitiGold banking program, and then all individuals with bank balances over a certain minimum amount, etc. These type of defined characteristics allow the owner of the system, such as a bank, to provide a perk to its best customers by insuring that they wait the least amount of time for an identification, for example. Further, these types of defined characteristics allow the system to individually tailored to define how a match determination is performed in order to best suit particular needs. Processor 22 of the local system may provide these subsets of image data by running a program to extract the subsets from stored image database 28, or

the subsets may be directly stored in the local or remote database or generated by a processor associated with the remote storage device.

Additionally, an ordered search may comprise performing a search based on binning the stored image metrics based on certain distinctive characteristics. Similar to above, this binning may occur locally or may be provided locally by the remote device. Typically, in two independent image sample acquisitions of the identical image, the resultant image metric in each case is not exactly identical. There is generally some degree of difference between the two image metrics due to the varying conditions of each acquisition and because of inherent error in the technique. This is especially true for images of individual irises. For example, if an iris comprises a digital image of 2000 bits, then in order to determine a good match only about 75% of the bits need to match. Out of the 75% of the bits that do match, there is a smaller percentage of bits that reliably match each time an image sample is acquired. The binning technique of the present invention identifies and utilizes the smaller, reliable number of bits that produce the match and bins the stored image metrics according to these bits. When an image of an iris is initially acquired and verified, a number of samples of the iris are taken and the resulting image metrics are compared to determine the bits that each sample have in common. These bits are then identified and utilized to bin the stored image metric. When a presented image is acquired, a number of samples are taken, the common bits are identified, and these common bits or some subset of them are utilized to select a bin to begin the match determination process.

This binning technique may have multiple embodiments. For example, the stored image metrics may be partitioned into multiple overlapping bins, where some number of bits that characterize each stored image metric are used to determine the bins. Each presented image metric maps to a single bin. Some stored image metrics may reside in multiple bins. Thus, if a match exists, the match is guaranteed to be in the bin.

Alternatively, the binning technique may partition the stored image metrics into multiple, non-overlapping bins. The unique bins in this case are determined by some number of bits that characterize the image metric. Each presented image metric maps to a small fraction of the total number of bins and these bins are then used in performing the matching search.

Further, a dynamic binning technique may be utilized. Dynamic binning utilizes images provided by a WFOV and a NFOV camera. When an individual's stored image metric is securely obtained, both a picture of their face and an iris image is captured and stored as the image metric. Then, in the later identification process, the system of the present invention captures a picture of the individual's face using the WFOV camera to capture the general individual characteristics as described above. Forming a portion of the presented image metric utilizing the general individual characteristics, a subset of possible matching stored image metrics is obtained by comparison with the stored image metric database. For each possible matching stored image metric, a confidence factor can be assigned to each possible matching stored image metric based on how close the presented individual characteristics match the stored individual characteristics. Then, the NFOV camera captures the individual's iris and the system generates the remainder of the presented image metric. The presented image metric is then compared to the possible matching stored image metrics to make an identification. Thus, the system limits the search to only the subset of stored image metrics having individual characteristics in common with the presented individual. This technique is advantageous because a face can be captured much more quickly than an iris and that allows the stored image database to be searched based on individual characteristics while the iris capture is completed.

Thus, as discussed above, the ordered search techniques of the present invention help to immediately narrow down the search field to the subset of stored image metrics that is most likely to contain a match. Therefore, the ordered search techniques immediately eliminate searching through and comparing image metrics that have

distinctive characteristics that obviously do not match the distinctive characteristics of the presented image metric.

Another embodiment of a match determine method comprises comparing the presented image metric to stored image metrics in a carousel system. The carousel system advantageously provides a plurality of access points to a high speed, constantly circulating database of stored image metrics. Processor 22, remote storage device 34 or a combination or plurality of both may comprise the carousel system to enable the high speed presentation of a series of stored image metrics. Alternatively, as opposed to a software controlled carousel system, multiple special purpose hardware devices may perform the carousel matching in hardware, each comprising a maximum number of stored image metrics in its buffer. The carousel system economically allows numerous match determinations to be performed simultaneously. For example, there may be a network of ATM's that utilize system 10 for identification purposes. Each ATM, and thus each system 10 may be networked to remote storage device 34. This arrangement may be necessary or desirable when the entire database of stored image metrics is only stored in one place or is too expensive to store locally, for example. The carousel system presents the stored image metrics, one at a time, to all the windows at the same order rather than having an individual search done for each presented image metric. The carousel system may present the entire stored image database in series, or the carousel system may present subsets of the entire stored image database, as discussed above. While each individual match determination for each of the plurality of presented images may not be customized, the carousel system beneficially increases the combined efficiency and reduces the total time of performing a match determination for the plurality of presented images. In effect, the carousel system allows for a plurality of systematic match determinations to be performed in parallel, as opposed to a plurality of match determinations to be performed in series. Thus, utilizing the carousel system is another way to improve the efficiency and speed of the fast matching identification system of the present invention.

Any of the above methods of match determination, or a combination thereof, may be used by system 10.

Further, once the presented image metric is compared to a stored image metric, a measurement of the degree of similarity between the two metrics is generated by processor 22. For example, the measurement may compare the two metrics on a bit-by-bit basis and total the number of bits that match identically and/or identify the bits that match. This measurement may be utilized in a decision to determine whether the presented image metric is similar enough to the stored image metric to be considered a match and thereby identify the individual. If no match is found, the system may return to the step of selecting a subset of image metrics, performing a carousel search, or end the process with a determination that the individual cannot be identified. If the measurement leads to a decision that the match is sufficient, then the process ends with the identification of the individual.

Thus, the present invention provides a fast matching system for personal identification that utilizes a number of methods to insure that an identification is made in the shortest possible time, within the order of a few seconds, and with a high degree of reliability.

Although the invention has been described with reference to these preferred embodiments, other embodiments can achieve the same results. Variations and modifications of the present invention will be apparent to one skilled in the art and the preceding disclosure is intended to cover all such modifications and equivalents.